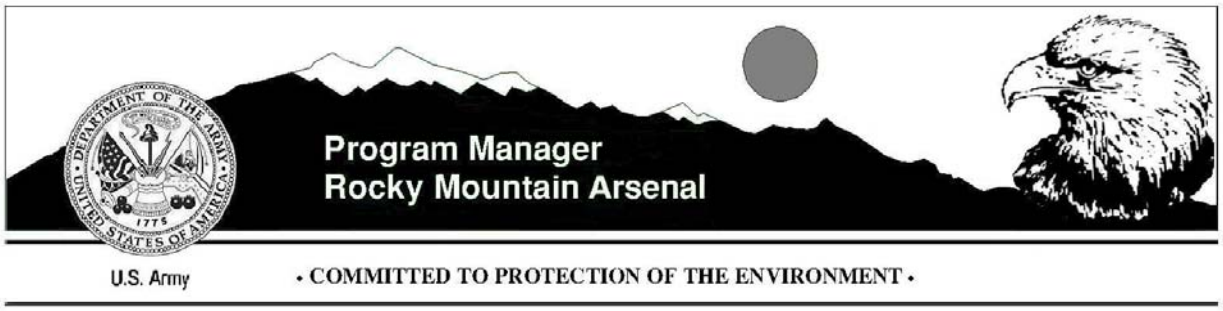


Revised Proposed Plan for the Rocky Mountain Arsenal On-Post Operable Unit Section 36 Lime Basins and Former Basin F

INTRODUCTION

This Revised Proposed Plan summarizes the **remedial alternatives**[1] evaluated and the U.S. Department of Army's (Army) preferred remedial alternative for cleanup of contamination at the Section 36 Lime Basins (Lime Basins) and Former Basin F (Basin F) areas at the Rocky Mountain Arsenal (RMA). The preferred remedial alternatives presented in this Revised Proposed Plan represent a change from the remedial alternatives selected in the **Record of Decision (ROD)** for the On-Post **Operable Unit** which was signed June 11, 1996. During design for the Lime Basins, it became apparent that actual conditions at the Lime Basins differed significantly from those discussed in the ROD. In particular, the remediation volume to be placed in the Enhanced Hazardous Waste Landfill (ELF) and short-term risks associated with the excavation increased significantly. A new remedy which does not require excavation of the Lime Basins is being proposed due to these changes and the related cost increase to implement the ROD-selected remedy.

A review of the overall RMA remediation identified contaminated soil in Basin F for

Opportunities for Public Involvement

Public Meeting
Thursday
May 12, 2005

Location
Commerce City Rec Center
6060 Parkway Drive
Commerce City, CO 80022

Time
6:30 pm to 8:00 pm

Administrative Record Location
Rocky Mountain Arsenal
Building 129, Room 2024
72nd Avenue and Quebec Street
Commerce City, CO 80022

Hours
Monday through Friday
Noon to 4:00 p.m.
or by Appointment

Telephone
Phone: (303) 289-0362

Public Comment Period
April 20 through May 20, 2005

Send Written Comments to
Revised Proposed Plan Comments
Rocky Mountain Arsenal
Attn: Peggy Machamer
Public Relations Office
Building 111
Commerce City, CO 80022

Or E-mail to
pao@rma.army.mil

[1]Items shown in **bold** are included in the glossary on page 24. Acronyms are also included in the glossary.

possible excavation and disposal in the potentially available volume in the ELF. Therefore, a new remedy for Basin F is also being proposed. The remedial alternatives for the two projects are evaluated here together because the preferred remedial alternative for Basin F is dependent on the selection of the preferred remedial alternative for the Lime Basins. Our goal is to ensure that the protectiveness of the overall remedy is not diminished.

This Revised Proposed Plan does not change the original selected remedy for groundwater, structures or any soil areas other than the Lime Basins or Basin F. The changes proposed to the remedy do not affect the Basin F Wastepile remedy. The remainder of the site-wide remedy is being implemented in accordance with the ROD.

This Revised Proposed Plan has been developed to inform the public of new preferred remedial alternatives for the Lime Basins and Basin F. These new alternatives were developed by the Army in cooperation with the regulatory agencies (U.S. Environmental Protection Agency [EPA], Colorado Department of Public Health and Environment [CDPHE], and the Tri-County Health Department [TCHD]). As the lead agency for the ROD-specified remedy, the Army is required to issue a Revised Proposed Plan when proposing an amendment to the ROD that fundamentally changes the remedial action and alters the basic features of the selected remedy with respect to scope performance or cost. This requirement is specified under Section 117 of the **Comprehensive Environmental, Response, Compensation, and Liability Act of 1980 (CERCLA)**, as amended by the Superfund Amendment and Reauthorization Act of 1986, and pursuant to the **National Contingency Plan (NCP)**, 40 Code of Federal Regulations (CFR) Section 300.435(c)(2)(ii).

This Revised Proposed Plan summarizes information that can be found in greater detail in the Summary of Remedial Alternatives for Section 36 Lime Basins and Former Basin F Principal Threat Soil Remediation Projects and other documents in the Administrative Record, which were used as the basis to select the preferred alternatives. The Support Agencies have reviewed the supporting documents and this Revised Proposed Plan and concur with the selection of the preferred alternatives. The Army, in consultation with the EPA and CDPHE, will select a remedial alternative and issue a ROD Amendment for the Lime Basins and Basin F after reviewing and considering all comments submitted during the public comment period. Therefore, the Army encourages the public to review all documentation regarding remediation of the Lime Basins and Basin F and to review and comment on all the alternatives presented in this Revised Proposed Plan.

WHAT ARE THE NEW PREFERRED ALTERNATIVES?

The preferred remedial alternative for cleanup of the Lime Basins is containment in place beneath a Resource Conservation and Recovery Act **(RCRA)-equivalent cover** (RCRA Subtitle C compliant alternative cover), vertical **groundwater barrier wall,** and dewatering within the barrier wall. The preferred remedial alternative for cleanup of the Basin F most highly contaminated soil is excavation and disposal in the on-post ELF. All activities for both projects would be conducted with appropriate air emission and odor controls as determined during design. The preferred alternatives were selected because they provide for greater overall protection of

human health and the environment at a lower cost, and provide short-term risk reduction by eliminating excavation of contaminated Lime Basins waste. The preferred alternatives can be accomplished in approximately the same time frame as and at a lower cost than the ROD-identified alternatives.

Site-wide institutional and engineering controls will apply to the Lime Basins and Basin F as well. In addition, RMA site-wide land use restrictions in accordance with the ROD, **Federal Facility Agreement (FFA)** and **Refuge Act** are applicable to both areas.

SITE BACKGROUND

RMA General

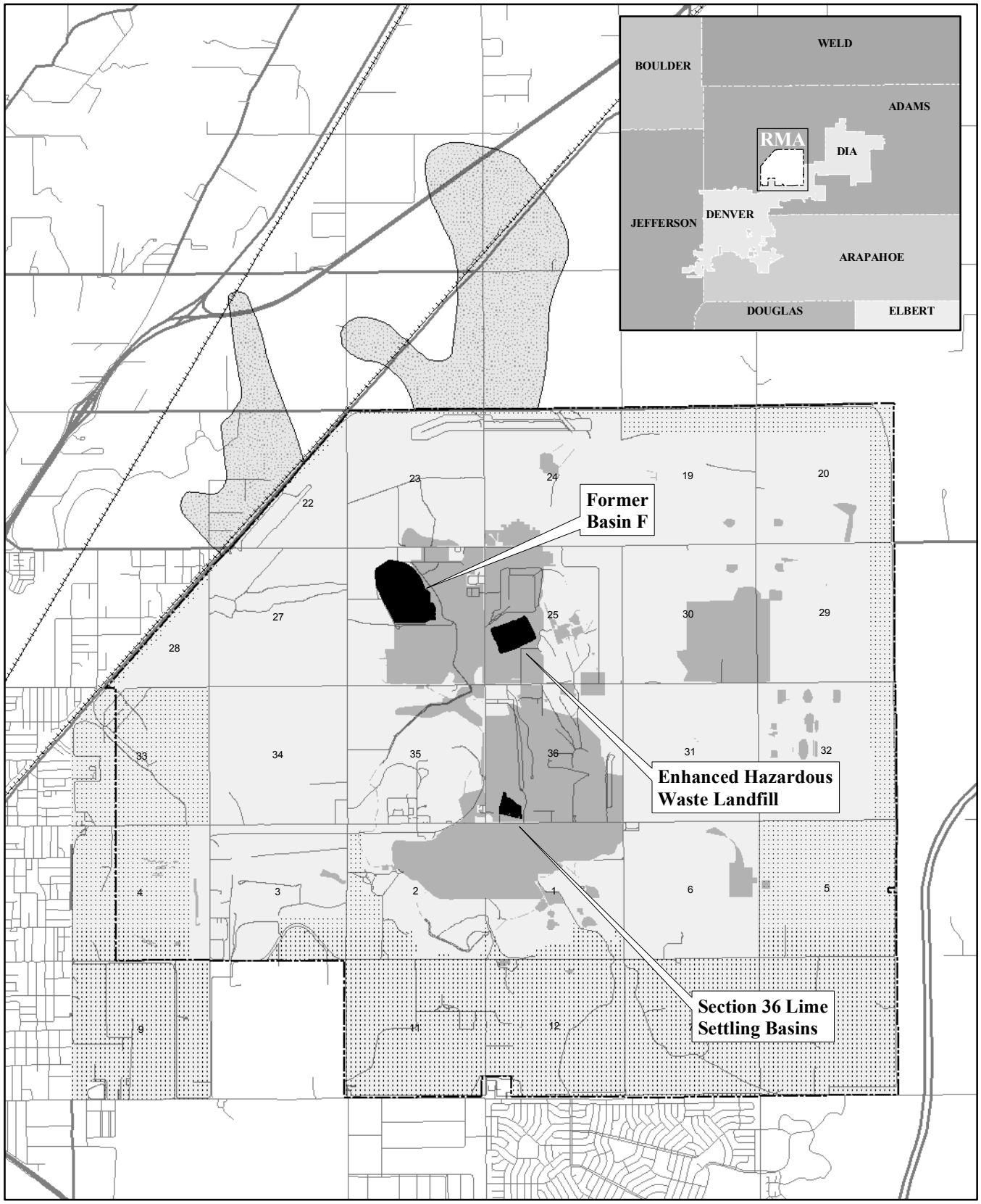
The RMA is a Federal Facility site located in southern Adams County, Colorado, approximately 10 miles northeast of downtown Denver and west of Denver International Airport. The RMA On-Post Operable Unit addresses contamination within the approximately 27 square miles of RMA. As of January 2005, 9.4 square miles of the On-Post Operable Unit have been determined to meet cleanup requirements and are no longer part of the National Priorities List (NPL) site. Implementation of the remedy for the remaining 17.2 square miles is ongoing and is scheduled for completion in 2012.

The Lime Basins cover approximately 5 acres and are located in the southwest corner of Section 36 of the RMA (Figure 1). Basin F covers approximately 93 acres and is located in Section 26.

The RMA was established in 1942 by the Army to manufacture chemical warfare agents and munitions for use in World War II. Following the war and through the early 1980s, the facilities continued to be used by the Army. Beginning in 1946, some facilities were leased to private companies, including Julius Hyman Company and Shell, to manufacture industrial and agricultural chemicals. Shell, the principal lessee, manufactured pesticides from 1952 to 1982 at the site.

Common industrial and waste disposal practices used during those years resulted in contamination of structures, soil, surface water, and ground water. In 1987, as a result of this contamination, the RMA was added to the NPL. On February 17, 1989, the Federal Facility Agreement, a document that formalizes the framework for remediating the Arsenal, was signed by the Army, Shell, EPA, U.S. Department of Justice, and Agency for Toxic Substances and Disease Registry. In October 1992, in conjunction with the future goal of open space and in recognition of the unique urban wildlife resources provided by the RMA, including the presence of bald eagles on site, President George H. Bush signed legislation, enacted by Congress, making most of the RMA a National Wildlife Refuge at the completion of remediation.

The overall selected remedy includes consolidation of **human health exceedance (HHE)** soil in the HWL, consolidation of soil with low levels of contamination to Basin A, and capping or covering additional areas where contamination is left in place. Sites where contamination is left in place require long-term institutional controls to further prevent future exposure to contaminants. The ROD requires monitoring and maintenance of all containment systems,



ROCKY MOUNTAIN ARSENAL
Lime Basins and Basin F Location Reference

Off-post Operable Unit
On-post Operable Unit
Implementation Project
Deleted from On-post Operable Unit
RMA Boundary (2005)

FIGURE 1

Map Document: D:\Map Documents\LB_BF_LocRefFig1.mxd

such as caps, covers, and landfills. In addition, land use restrictions prohibit the use of RMA for residential and agricultural purposes, the use of groundwater located under or surface water located on RMA as a source of potable water, and the consumption of fish and game taken on RMA.

Section 36 Lime Basins

The Lime Basins, constructed in 1942, were designed to remove arsenic from South Plants wastewater and to receive other aqueous waste from South Plants. There were three basins constructed, each approximately 1 acre in size and 15 feet deep. Through November 1943, wastewater from the production of Lewisite was routinely treated with lime prior to discharge to the unlined Lime Basins and subsequently discharged by gravity flow into Basin A, located just north of the Lime Basins. The lime was used to precipitate metals and reduce the arsenic concentration in the wastewater. This precipitation process produced a lime sludge that contained high levels of heavy metals, including arsenic.

After Lewisite manufacturing ceased in November 1943, the Army stopped putting lime slurry into the Lime Basins. The Lime Basins continued to receive aqueous waste from South Plants, from both Army and Shell productions, including pesticide production wastewater. Those wastes were transported through two chemical sewers that discharged into the south side of the Lime Basins. In January 1957, both the Army and Shell ceased using Basin A and the Lime Basins for aqueous waste following the completion of Basin F and the chemical sewer lines leading to Basin F.

Between 1950 and 1974, acetylene production by Shell generated lime as a by-product. That lime was deposited as a slurry in the Lime Pond located within the South Plants manufacturing area in Section 2. Between 1955 and 1963, Shell periodically hauled lime waste from the South Plants Lime Pond to the Lime Basins. In late 1963, a three-inch pipe line was installed to transfer the lime slurry directly from South Plants to the Lime Basins. Lime slurry was disposed in this manner until July 1974. In 1974 or 1975, the Army bulldozed the embankments of the Lime Basins and leveled them off with the existing ground surface. Aerial photographs from 1975 indicate the basins were no longer in use and had been filled in.

In 1993, an **Interim Response Action (IRA)** was completed for the Lime Basins to address groundwater contamination from the basins. The IRA for the Lime Basins was to include relocation of sludge material from outside the basins to within the basin area, a subsurface barrier around the basins, groundwater extraction system, and a soil vegetative cap over the Lime Basins.

During excavation for construction of the slurry wall and groundwater extraction system at the site, munitions debris was discovered. As a result, only the minimum 18-inch thick vegetative cap and storm sewer line to route drainage around the south and east sides were constructed. The subsurface barrier and groundwater extraction system were not installed. The IRA soil cover and storm sewer remain in place at the Lime Basins.

Former Basin F

The Basin F surface impoundment was constructed to contain liquid wastes from Army and Shell chemical operations, including the Chlorine Plant, Shell Manufacturing Area and the Sarin (GB)

complex. Construction of Basin F occurred between July and December 1956 in a natural depression located immediately north of Basin C. The impoundment was created by constructing an elevated berm around the natural depression and lining the basin with a 3/8-inch asphalt membrane. A 1-foot-thick soil protective layer was placed on top of the asphalt membrane. The impoundment had a surface area of approximately 93 acres and a capacity of approximately 243 million gallons.

Basin F was used continuously between December 1956 and December 1981 for evaporation of contaminated liquid wastes. In the spring and summer of 1957, repairs were made to the liner and protective soil layer of Basin F, which had been damaged by severe wave action within the basin. In the summer of 1964, the Army constructed an earthen fill dike across the southeast corner of Basin F, creating a 1-million-gallon surge basin identified as F-1. When F-1 was completed, liquid waste discharge from the chemical sewer bypassed Basin F and was taken directly to the Deep Well Injection Facility.

In December 1981, the Army implemented a series of measures designed to 1) accelerate the evaporation of the remaining liquids in the basin, 2) prevent sewer-transported flows from infiltrating both ground and surface waters, and 3) prevent surface runoff from generating additional liquid waste volumes contained in the basin. The basin was preliminarily closed by the removal of all conveyance systems into the basin on July 14, 1982.

An IRA for the Basin F hazardous liquid waste, sludge, and soil was performed between 1988 and 1996. The IRA was conducted to prevent potential infiltration of contamination from the basins to the underlying groundwater, eliminate potential adverse impacts to wildlife, and eliminate emissions of volatile chemicals from the basin. Liquid waste was removed from the basin and incinerated at a facility built on-site. The nonliquid wastes (approximately 480,000 cy of contaminated soil, crystalline sludge, sludge, overburden and asphalt liner) were partially dried and then consolidated, thereby creating the Basin F Wastepile. Following the removal of the wastes, a minimum 2-ft thick soil cover was installed over the entire Basin F.

SITE CHARACTERISTICS

Lime Basins

Investigation of the Lime Basins was conducted during the **Remedial Investigation (RI)** and **Feasibility Study (FS)**. Gray to white lime material was present in soil borings taken within the basins and was also observed within the soil outside the basins. The **contaminants of concern (COCs)** identified at the Lime Basins include organochlorine pesticides (OCPs), arsenic and mercury. These COCs are present throughout the sludge and in the soil surrounding the Lime Basins.

Table 1 provides a summary of the COCs and concentrations for soil data collected for the Lime Basins. Approximately 80,000 bank cubic yards (bcy) of soil contain concentrations of OCPs and arsenic that exceed human health risk criteria (referred to as HHE soil) as well as biota risk criteria. An additional 9,000 bcy have concentrations of aldrin and dieldrin above the **principal threat** (PT) criteria. The PT soil was identified primarily within the basins resulting from samples exceeding the PT criteria at one location within the basins. The total remediation soil volume for the Lime Basins soil project was modified

during design from the ROD volume of 54,151 bcy to 89,450 bcy. Figure 2 shows the Lime Basins project boundaries.

Table 1. Lime Basins Contaminants of Concern

COC	Maximum Concentration (ppm)	Average Concentration (ppm)	HHE Criteria (ppm)	Principal Threat Criteria (ppm)
Aldrin	310,000	5,995	71	720
Chlordane	730	89.6	55	3,700
Dieldrin	2,100	55.8	41	410
Endrin	1,100	33.1	232	232,000
Isodrin	810	46.7	52	52,400
DDE	31	2.7	1,250	13,000
DDT	8.6	1.3	409	14,000
Arsenic	1,100	43.4	417	4,200
Mercury	110	2.3	574	574,000

Groundwater sampling conducted during the RI indicated that the Lime Basins are a source of groundwater contamination. In the southern portion of the Lime Basins, the bottom 2 to 3 feet of waste (approximately 15 feet depth) is currently within the groundwater aquifer. Major contaminants present in the groundwater in the Lime Basins area include OCPs, arsenic and VOCs. Groundwater flow from the Lime Basins is to the northwest and is currently captured and treated at the Basin A Neck treatment facility.

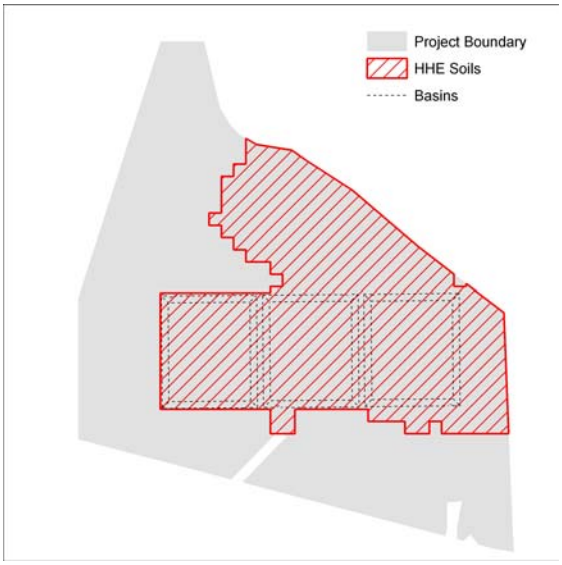


Figure 2 Lime Basins Project Area

A treatability study for the Lime Basins was performed in 2000 to determine the best method for excavation and disposal of the Lime Basins material in the ELF. Data from the treatability study indicated that some of the material failed the **paint filter test (PFT)** and would require mixing with additives such as the surrounding drier soil and shredded newspaper to control moisture and stabilize the waste. Geotechnical analysis and a field demonstration soil mixing study were performed in the fall of 2002. The results of the field study indicated that a mix ratio of surrounding soil to Lime Basins material of 3:1 would produce a product that would pass the PFT and could be effectively compacted in the ELF. This remediation technique was included in the Lime Basins 60 percent design due to its relative ease of construction and use of on-site materials.

Basin F

Initial sampling in Basin F was conducted during the RI. In the southern and eastern areas of the basin, where the physical integrity of the liner was poor, samples were found to contain elevated concentrations of organic contaminants to depths of 20 feet

below ground surface. The concentrations in these locations remained relatively uniform with depth, and high concentrations of many contaminants occurred in the soil at or above the water table elevation. In contrast, moderate to low contaminant concentrations were detected in most samples taken where the liner was still intact and concentrations decreased with depth.

Table 2. Basin F Contaminants of Concern

COC	Maximum Concentration (ppm)	Average Concentration (ppm)	HHE Criteria (ppm)	Principal Threat Criteria (ppm)
Aldrin	5,700	1,245	71	720
Dieldrin	3,900	528	41	410
Endrin	2,100	419	232	232,000
Isodrin	11,000	1,025	52	52,400
DCPD	22,000	2,289	3,690	NA
CLC2A	8,000	1,610	77	77,100

Additional RI sampling was conducted during the IRA after the overburden, liner and some of the underlying soils were removed. The results from this program generally paralleled the results of the RI sampling effort, resulting in the identification of approximately 233,000 bcy of PT soil. This volume includes approximately 165,000 bcy of actual PT soil, 52,000 bcy of overlying HHE soil and 16,000 bcy of interbedded HHE soil.

Table 2 provides a summary of the COCs and concentrations for soil data collected within the PT soil areas in Basin F. Concentrations of OCPs, dicyclopentadiene (DCPD) and chloroacetic acid (CLC2A) are well above the HHE criteria. Also, concentrations of aldrin and dieldrin are above the PT criteria. The total remediation soil volume for the Basin F soil project was modified during design from the ROD volume of 266,708 bcy to 233,000 bcy. The location of the PT soil area in Basin F is shown on Figure 3.

Groundwater sampling conducted during the RI indicated that Basin F is a source of groundwater contamination. Depth to groundwater in the Basin F area ranges from 20 feet to more than 40 feet. Major contaminants present in the groundwater in the Basin F area include chloroform, benzene, trichloroethylene, dieldrin, DIMP, and dibromochloropropane. Groundwater flow from Basin F is to the north and is currently captured and treated at the North Boundary Containment System.

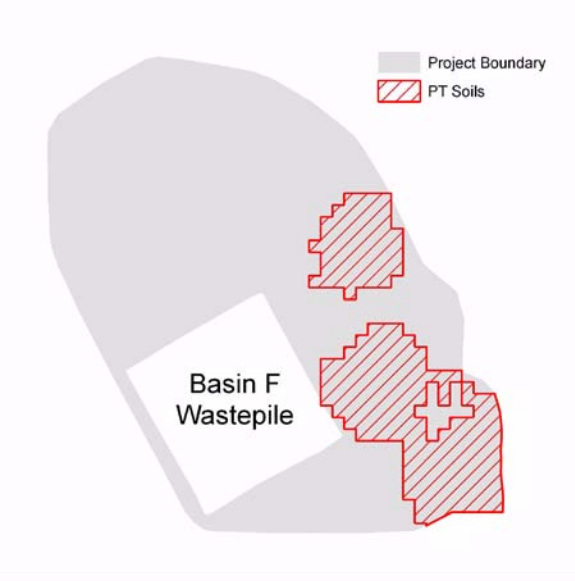


Figure 3 Basin F Project Area

SCOPE AND ROLE OF THE RESPONSE ACTION

This response action will address contamination at two of the most contaminated soil areas within the On-Post Operable Unit, the Lime Basins and Basin F projects. The On-Post Operable Unit is one of two primary operable units at RMA. Contaminated areas addressed in the On-Post ROD include groundwater plumes, contaminated structures and contaminated soil. The Off-Post Operable Unit addresses contamination in groundwater north and northwest of RMA. The final ROD for the Off-Post Operable Unit was issued in December 1995 and is being implemented.

This Revised Proposed Plan does not change the 1995 Off-Post remedy or the 1996 On-Post remedy for groundwater, structures or any soil area other than the Lime Basins and Basin F. The changes proposed to the remedy do not affect the Basin F Wastepile remedy. The preferred remedial action in this revised proposed plan will address all contamination at the Lime Basins and will be the final response action for the project. For Basin F, this revised proposed plan will address PT soil contamination within the basin and, in combination with construction of the required RCRA-equivalent cover over the basin, will be the final response action for this project as well.

SUMMARY OF SITE RISKS

At RMA, a risk assessment called the Integrated Endangerment Assessment/Risk Characterization was performed and used as the baseline risk assessment for the 1996 ROD. The 1996 ROD contains a summary of the risk assessment performed for the on-post operable unit, including the Lime Basins and Basin F. Both are identified as having PT soils, meaning that contamination poses a threat to human health and biota. The COCs detected above the PT criteria are aldrin and dieldrin in both the Lime Basins and Basin F. In addition, both areas have been classified as identifiable sources of groundwater contamination.

During the risk assessment, site-specific risks were calculated for all RMA soil contamination areas. Direct exposure pathway risks were calculated for soil intervals of 0-1 ft and 0-10 ft depths. These depths were considered because they represent the most likely soil exposure depths for the on-site biological worker population (on-site U.S. Fish and Wildlife Service worker or a contractor). For biota (or wildlife) risks, the 0-1 ft depth interval was considered the primary exposure interval. Therefore, remedial alternatives were subsequently developed to address these depth intervals (0-10 ft for HHE and 0-1 ft for biota) in order to break potential exposure pathways.

It is the Army's current judgment that the preferred alternatives identified in this Revised Proposed Plan, or implementation of the other remedial alternatives considered, is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) for the RMA On-Post Operable Unit were established during the FS, which is the basis of the 1996 ROD. The RAOs identified for the soil medium (which includes the Lime Basins and Basin F) were incorporated in the 1996 ROD, Section 7.4.2, as stated below:

Human Health

- Prevent ingestion of, inhalation of, or dermal contact with soil or sediments containing COCs at concentrations that result in risks that exceed $1x10^{-4}$ (carcinogenic) risk or a hazard index (HI) greater than 1.0 (noncarcinogenic) based on the lowest calculated reasonable maximum exposure (5^{th} percentile) preliminary pollutant limit values (PPLV), which generally represent the on-site biological worker population).
- Prevent inhalation of COC vapors emanating from soil or sediments in excess of acceptable levels, as established in the Human Health Risk Characterization.
- Prevent migration of COCs from soil or sediment that may result in off-post groundwater, surface water or windblown particulate contamination in excess of off-post remediation goals.
- Prevent contact with physical hazards such as unexploded ordnance.
- Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Ecological Protection

- Ensure that biota are not exposed to COCs in surface water, due to migration from soil or sediment, at concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.
- Ensure that biota are not exposed to COCs in soil and sediments at toxic concentrations via direct exposure or bioaccumulation.

ROD REMEDY

The primary components of the remedy selected for the Lime Basins in the 1996 On-Post ROD are as follows:

- Remove the existing soil cover and set aside.
- Excavate principal threat and human health soil and dispose in a triple-lined cell at the on-post hazardous waste landfill facility.
- Conduct chemical agent monitoring during excavation activities. Caustic washing of any agent-contaminated soil found during excavation.
- Conduct remediation activities using vapor- and odor-suppression measures as required.
- Backfill the excavation with clean borrow and repair the existing soil cover.

The primary components of the remedy selected for Basin F in the 1996 On-Post ROD are as follows:

- Treat principal threat soil using in situ **solidification/stabilization** technology.
- Perform treatability testing during remedial design to identify an appropriate mixture of solidification reagents, verify the effectiveness of the solidification/stabilization process and establish operating parameters for the design of the full-scale operation.
- Conduct remediation activities using vapor- and odor-suppression measures as required.
- Construct RCRA-equivalent cover over the entire Basin F area (including the Basin F Wastepile footprint).

SUMMARY OF REMEDIAL ALTERNATIVES

This revised Proposed Plan includes a discussion of the ROD-selected remedies and proposed alternate remedies developed to address contamination at the Lime Basins and Basin F. The No Action alternatives were also identified. Remedial alternatives are summarized for the Lime Basins on Table 3 and for Basin F on Table 4. These alternatives are all consistent with the future land use for most of the other areas of RMA as a wildlife refuge and with remedial alternatives developed during the FS. A more detailed description of these alternatives can be found in the Summary of Remedial Alternatives for Section 36 Lime Basins and Former Basin F Principal Threat Soil Remediation Projects.

Common Remedial Alternative Elements

All of the alternatives have several features in common as follows:

- Engineering and Institutional Controls – Because all alternatives include a soil cover for both the Lime Basins and Basin F, all engineering controls required for covers are applicable to the Lime Basins and Basin F. Engineering controls include warning signs, fences with visual barriers for wildlife, and boundary markers around the covered areas. These controls, as well as long-term operations and maintenance requirements for the covers, will be described in the site-wide Long-Term Care Plan (under development). In addition, site-wide institutional controls restricting land use for the entire RMA site are applicable to the Lime Basins and Basin F.
- Groundwater Treatment - Contaminated groundwater from both project areas is currently captured and treated at existing on-site treatment facilities. These groundwater treatment facilities continue to operate.
- Long-Term Monitoring – Groundwater monitoring to assess remedy effectiveness is performed on a site-wide basis.
- Five-Year Review – In accordance with CERCLA, a review will be performed at least every 5 years for all RMA, including Lime Basins and Basin F, to ensure the remedy remains protective of human health and the environment.
- Costs associated with design activities to date for the Lime Basins and Basin F are not included in the cost estimates for the alternatives evaluated here.

Lime Basins Alternative 1: No Further Action (Existing IRA Soil Cover)

The evaluation of a no action alternative is generally required to establish a baseline for comparison of remedial alternatives. Under this alternative, no additional action specific to the Lime Basins would be taken. The Lime Basins material would remain in place and the soil cover constructed as part of the Lime Basins IRA would continue to act as containment for the waste. Long-term groundwater monitoring would be required to assess effectiveness. Key **Applicable or Relevant and Appropriate Requirements (ARARs)** relating to this remedy are those regulations pertaining to groundwater monitoring.

The estimated cost for implementing this alternative includes an annual Operation and Maintenance (O&M) cost of $48,200. The total estimated present worth cost is $656,000. These costs include groundwater sampling and analysis costs to assess any migration of the waste left in place, and cover inspection and maintenance costs. There is no design or construction required for this alternative.

Lime Basins Alternative 2: Excavate; On-Post Landfill; Repair IRA Cover (ROD Remedy)

The HHE soil volume of 89,450 bcy is excavated, transported to and disposed in the ELF. Treatability studies performed in support of design identified that the wet portion of the Lime Basins material would require stabilization prior to disposal to allow proper compaction. The 60 percent design incorporated mixing of the wet Lime Basins material with surrounding dry soil prior to disposal in the ELF, increasing the ELF disposal volume to approximately 130,000 bcy. The additional material handling and mixing requirements result in an increased potential for emissions and odors. Excavation activities require shoring of side slopes to prevent the excavation walls from collapsing. Air emissions and odor controls would be applied as necessary during excavation, transportation and placement of waste in the ELF. Chemical agent monitoring and inspection for potential ordnance items is required during excavation as well. The excavation would be backfilled using on-post borrow material and the existing IRA soil cover would be repaired.

This Alternative for the Lime Basins cannot be implemented if Alternative 3 (Excavate Principal Threat Soil; On-Post Landfill) is selected for the Basin F project. Key ARARs relating to this remedy are regulations pertaining to waste management/on-post disposal, stormwater and erosion control, particulate and odor emissions, and groundwater monitoring.

The estimated cost for implementing this alternative includes an estimated capital cost of $16,400,000 and estimated annual O&M cost of $48,200. The total estimated present worth cost, including long-term groundwater monitoring and cover maintenance costs, is $17,100,000. This cost differs significantly from the ROD-estimated cost of $4,000,000 as a result of the new information developed

Table 3. Summary of Remedial Alternatives for the Lime Basins

Remedial Alternative	Description
Alternative 1: No Further Action (Existing IRA Soil Cover)	No additional action specifically for the Lime Basins. The basins are contained beneath the existing 18-inch soil cover that was constructed as part of the IRA for the Lime Basins.
Alternative 2: Excavate and Dispose in ELF; Repair existing IRA soil cover	Contaminated soil and lime material are excavated and disposed in the on-post ELF. Air emissions and odors are controlled during excavation and landfill activities. The site is backfilled and the existing IRA soil cover is repaired.
Alternative 3: Vertical Groundwater Barrier; Dewatering with On-Site Treatment; RCRA-Equivalent Cover	Install a vertical groundwater barrier keyed into competent bedrock to isolate the Lime Basins. Install dewatering wells within the barrier wall; treat contaminated groundwater at on-site facilities. Construct a RCRA-equivalent cover over the entire Lime Basins project area.

during the design treatability studies. Implementation for design and construction of this alternative is expected to take approximately 21 months.

Alternative 3: Vertical Groundwater Barrier; Dewatering with On-Site Treatment; RCRA-Equivalent Cover

A vertical groundwater barrier wall is constructed fully encompassing the three historic Lime Basins to prevent migration of groundwater through the buried waste soil. The barrier wall is keyed into competent bedrock. Exact depths of the barrier wall will be incorporated in the project design after analysis of the Lime Basins investigation results has been completed. A dewatering well or wells are installed inside the barrier wall to extract groundwater and maintain a positive flow from the outside to the inside of the barrier wall. The dewatering wells will lower groundwater levels below the identified Lime Basins contamination and remove contaminant mass by treatment of the extracted groundwater. Extracted groundwater is treated at an on-site water treatment facility.

After construction of the vertical barrier is completed, a RCRA-equivalent cover would be constructed over the area. The cover would be contiguous with the Basin A and South Plants RCRA-equivalent covers because the Lime Basins area is located between these cover areas. Key ARARs relating to this remedy are regulations pertaining to particulate and odor emissions, stormwater/erosion control and groundwater monitoring. Figure 4 shows the extent of the RCRA-equivalent cover and two potential alignments for the barrier wall. The final alignment for the barrier wall will be determined during design.

The estimated present worth cost for implementing this alternative includes an estimated capital cost of $7,600,000 and estimated annual O&M cost of $258,000. The total estimated present worth cost is $10,900,000. Implementation for design and construction of this alternative is expected to take approximately 18 months. Compatibility testing of groundwater with selected vertical barrier materials would be completed during design.

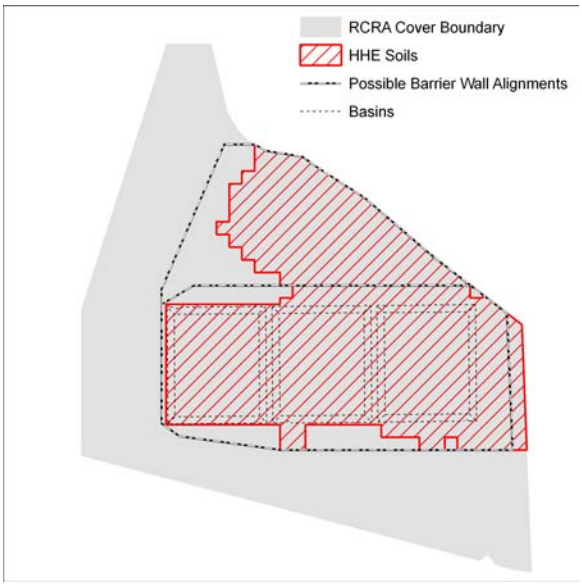


Figure 4 Lime Basins Alternative 3

Basin F Alternatives – Common Elements

The current Basin F remedy includes construction of a RCRA-equivalent cover with biota barrier over the Basin F and Basin F Wastepile areas. Construction of the cover is required to provide containment for HHE soil and PT soil (including solidified soil if treated, and residual PT soil deeper than 10 feet if excavation is performed). Construction of the cover will be completed under the Basin F/Basin F Exterior Project. The discussion in this document concerning remedial options for the Basin F PT soil does not propose any change to the RCRA-equivalent cover requirement. Because the

cost of the cover is already included in the cost for the Basin F/Basin F Exterior Project, the remedial alternatives discussed here do not include costs for cover construction or maintenance. Implementation times do not include the time required to design and construct the cover.

Basin F Alternative 1: No Further Action (RCRA-Equivalent Cover)

Under this alternative, no additional action specific to Basin F PT soil would be taken. The contaminated soil would remain in place and, once the ROD-required RCRA-equivalent cover was constructed, the PT soil would be contained beneath the cover. Gradefill material would be placed over the site followed by construction of the cover. There are no changes proposed for the RCRA-equivalent cover requirements. Long-term groundwater monitoring would be required to assess effectiveness. Key ARARs relating to this remedy are regulations pertaining to particulate and odor emissions, stormwater/erosion control and groundwater monitoring. Because construction of the cover and groundwater monitoring are already included in the Basin F/Basin F Exterior project, there are no cost or schedule impacts for this alternative.

Basin F Alternative 2: In Situ Solidification/Stabilization of Principal Threat Soil; [RCRA-Equivalent Cover] (ROD Remedy)

Approximately 165,000 bcy of PT soil is treated using in situ solidification/ stabilization. Treatability studies have been conducted to identify solidification reagents in preparation for remedial design and a successful mix of reagents has been identified. The treatment consists of properly mixing the solidification reagents directly into the soil. Treatment is completed to a depth of 10 feet below the excavation surface from the IRA. Air emissions and odor controls would be applied as necessary during treatment.

Following completion of the treatment process, gradefill material would be placed over the site followed by construction of the RCRA-equivalent cover. There are no changes proposed for the RCRA-equivalent cover requirements. Long-term groundwater monitoring would be required to ensure effectiveness. Key ARARs relating to this

Table 4. Summary of Remedial Alternatives for the Basin F Principal Threat Soil

Remedial Alternative	Description
Alternative 1: No Further Action [RCRA-Equivalent Cover]	No additional action specifically for the Basin F principal threat soil. The entire basin will be contained beneath the RCRA-equivalent cover specified in the ROD for remediation of human health soil.
Alternative 2: In situ Solidification/ Stabilization of Principal Threat Soil [RCRA-Equivalent Cover]	Principal threat soil is treated through in situ solidification/ stabilization. Air emissions and odors are controlled during treatment. (A RCRA-equivalent cover will be constructed over the entire Basin F project area for remediation of the human health soil.)
Alternative 3: Excavate Principal Threat Soil and Dispose in ELF [RCRA-Equivalent Cover]	Principal threat soil is excavated and disposed in the on-post ELF. Air emissions and odors are controlled during excavation and landfill activities. The excavation is backfilled. (A RCRA-equivalent cover will be constructed over the entire Basin F project area for remediation of the human health soil.)

remedy are regulations pertaining to particulate and odor emissions, stormwater/erosion control and groundwater monitoring.

The estimated cost for implementing this alternative includes an estimated capital cost of $36,200,000. Annual O&M costs, for cover maintenance and groundwater monitoring, are associated with the Basin F/Basin F Exterior project and are not included here. This cost decreased from the ROD-estimated cost of $42 million based on the mix of reagents identified during the design treatability studies. Implementation for design and construction of this alternative is expected to take approximately 29 months.

Basin F Alternative 3: Excavate Principal Threat Soil; On-Post Landfill; [RCRA-Equivalent Cover]

The existing IRA soil cover and gradefill is removed as overburden and set aside. Excavation of PT soil is completed to a maximum depth of 10 feet from the previous IRA excavation surface. Approximately 165,000 bcy of principal threat soil is excavated, transported to the ELF and disposed. In order to minimize potential emissions impacts from soil handling, HHE soil overlying or interbedded with PT soil is also excavated and disposed in the ELF. The total excavation volume is estimated at 233,000 bcy. Stockpiled cover soil and gradefill are used as backfill for the excavation. Excavation, transportation, and disposal of PT soils are conducted using vapor and odor suppression measures as necessary.

The residual soil remaining in Basin F would be contained in place beneath the ROD-required RCRA-equivalent cover as part of the Basin F/Basin F Exterior Soil Remediation Project. Residual soil includes HHE soil identified in the ROD as well as HHE and PT soil located greater than 10 feet below the IRA excavation surface. There are no changes proposed to the RCRA-equivalent cover requirements.

This Alternative for Basin F cannot be implemented if Alternative 2 (Excavate; On-Post Landfill) is selected for the Lime Basins project. Key ARARs relating to this remedy are regulations pertaining to particulate and odor emissions, stormwater/erosion control, waste management/on-post disposal and groundwater monitoring.

The estimated cost for implementing this alternative includes an estimated capital cost of $14,500,000. Annual O&M costs, for cover maintenance and groundwater monitoring, are associated with the Basin F/Basin F Exterior project and are not included here. Implementation for design and construction of this alternative is expected to take approximately 26 months.

EVALUATION OF ALTERNATIVES

The NCP identifies nine criteria to be used in the evaluation of remedial alternatives as described in Table 5. Each remediation alternative is evaluated individually and against one another to select a remedy. Criteria 1 and 2 are considered threshold criteria that each alternative must meet to be eligible for selection. Criteria 3 through 7 are considered primary balancing criteria because they are used to weigh major trade-offs between alternatives to achieve the best overall solution taking into account technical, cost, institutional and risk considerations. Criteria 8 and 9 are modifying criteria and can be fully considered only after public comment is

received on the Proposed Plan. In the final balancing of trade-offs between alternatives, modifying criteria can have a significant impact on the final remedy selection.

This section provides an evaluation of each alternative against the nine criteria, noting how it compares to the other alternatives being considered. For purposes of comparison, Tables 6 and 7 provide a side-by-side summary of the evaluation of the three alternatives for the Lime Basins and Basin F, respectively.

1. Overall Protection of Human Health and the Environment

Lime Basins Alternatives 2 (Excavate/Landfill) and 3 (Vertical Barrier/RCRA-Equivalent Cover) would provide protection of human health and the environment by reducing risk through containment either in the ELF or in place. Alternative 3 includes a groundwater barrier wall and dewatering within the barrier wall to provide adequate containment. The No Further Action alternative (Alternative 1) would provide protection of human health through in-place containment of the contaminated soil; however, biota RAOs would not be achieved since the existing IRA cover does not include a biota barrier. Alternative 1 (No Further Action) also relies on continuation of existing groundwater treatment to achieve overall protection, since waste is currently in contact with the groundwater. The most protective alternative is Alternative 2 (Excavate/ Landfill) because it provides isolation of

Table 5. Evaluation Criteria for CERCLA Remedial Alternatives

1. Overall Protection of Human Health and the Environment determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to a site or whether a waiver is justified.
3. Long-Term Effectiveness and Permanence considers the ability of an alternative to maintain protection of human health and the environment over time.
4. Reduction of Toxicity, Mobility or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
5. Short-Term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
6. Implementability considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
7. Cost includes estimated capital and annual operations and maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
8. Regulatory Agency Acceptance considers whether EPA and the State agree with the Army's analyses and recommendations, as described in the Technical Summary and Proposed Plan.
9. Community Acceptance considers whether the local community agrees with the Army's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

wastes in the on-site ELF rather than relying on in-place containment.

For Basin F, all of the alternatives would provide protection of human health and the environment by reducing risk through containment, treatment or a combination of both. Alternative 1, (No Further Action), is also expected to provide adequate protection because the Basin F RCRA-equivalent cover will be constructed regardless of the remedy selected for remediation of Basin F PT soil. Alternative 2 (In Situ Solidification/ Stabilization of PT Soil) includes solidification to minimize potential migration of contaminants; however, treated soil is left in place. Alternatives 1 and 3 rely on continuation of existing groundwater treatment to achieve overall protection to address potential migration of contaminants to groundwater. Alternative 3 (Excavate/Landfill PT Soil) is the most protective overall because it provides isolation of wastes in the on-site ELF rather than relying on in-place containment.

2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

All the alternatives would attain their respective ARARs from Federal and State laws. A more detailed review of ARARs associated with each alternative is presented in the **Detailed Analysis of Alternatives**, Volume VII, Appendix A.

3. Long-Term Effectiveness and Permanence

Lime Basins Alternative 2 (Excavate/ Landfill) achieves long-term effectiveness with the least residual risk. Landfill controls provide adequate and reliable containment with appropriate long-term monitoring and maintenance. Alternative 3 (Vertical Barrier/ RCRA-Equivalent Cover) also achieves long-term effectiveness; however, containment in the ELF is considered more reliable than containment in place and results in less volume, or residual risk, remaining in the project area. In addition, Alternative 3 relies on the vertical groundwater barrier wall and dewatering wells to provide adequate containment. Alternative 1 (No Further Action, IRA Cover) provides a two-foot soil barrier to exposure that also lessens the potential migration of contaminants through containment under the existing cover. Long-term monitoring would be required for all alternatives to assess effectiveness.

Basin F Alternative 3 (Excavate/Landfill PT Soil) achieves long-term effectiveness with the least residual risk. Landfill controls provide adequate and reliable containment with appropriate long-term monitoring and maintenance. Alternative 2 (In Situ Solidification/ Stabilization of PT Soil) also achieve long-term effectiveness through a combination of in-place treatment and containment; however, containment in the ELF is considered more reliable than containment in place and results in less volume, or residual risk, remaining in the project areas. Alternative 1 (No Further Action, RCRA-equivalent Cover) would reduce exposure and migration of contaminants through containment in place. Long-term monitoring would be required for all alternatives to assess effectiveness.

Implementing Alternative 3 for both projects provides an overall gain in long-term effectiveness since a higher volume of PT soil is excavated and disposed in the ELF, 165,000 bcy from Basin F compared to 9,000 bcy for Lime Basins Alternative 2.

4. Reduction of Toxicity, Mobility or Volume (TMV) through Treatment

None of the alternatives for the Lime Basins involve treatment of the Lime Basins waste, relying instead on containment for reduction of mobility. Alternative 3 (Vertical Barrier/ RCRA-Equivalent Cover) does include treatment of extracted groundwater, which reduces the toxicity and volume of contaminants. There is no reduction in toxicity, mobility or volume through treatment for Alternative 1 (No Further Action, IRA cover) or Alternative 2 (Excavate/Landfill). Note that for Alternative 2 the Lime Basins volume increases due to soil mixing requirements for disposal in the ELF.

For Basin F, Alternative 2 (In Situ Solidification/Stabilization of PT Soil) reduces the mobility of the contaminants through the solidification treatment. However, there is an increase in volume due to the addition of solidification reagents introduced during the treatment process. Alternative 1 (No Further Action, RCRA-equivalent cover) and Alternative 3 (Excavate/Landfill PT Soil) do not result in reduction in mobility or volume through treatment, relying on containment for reduction of mobility. There is no reduction in toxicity for any alternative.

5. Short-Term Effectiveness

Lime Basins Alternative 2 (Excavate/Landfill) requires excavation of contaminated materials and therefore presents the highest potential for short-term risks to on-site workers. Air and odor controls would be required to mitigate the risks from excavation activities. Short-term risks are considerably higher than anticipated during the ROD due to increased volume and multiple material handling requirements to allow placement of soil in the ELF. Additional short-term risks associated with Lime Basins excavation include excavation slope stability, potential for chemical agent contamination and presence of anomalies requiring clearance during excavation. Alternative 3 (Vertical Barrier/RCRA-Equivalent Cover) presents a moderate potential for short-term risk due to the potential for emissions and odor during intrusive activities associated with the barrier wall construction and dewatering well installation. Alternative 1 (No Further Action, IRA Cover) poses the least short-term risk since the waste is contained in place and would not be disturbed.

For Basin F, Alternative 3 (Excavate/ Landfill PT Soil) requires excavation of contaminated materials and therefore presents the highest potential for short-term risks to on-site workers. Alternative 2 (In Situ Solidification/Stabilization of PT Soil) also presents a moderate potential for short-term risk during in-place soil mixing to achieve stabilization of the PT soil. Air and odor controls would be required to mitigate the risks from excavation or treatment activities. Alternative 1 (No Further Action, RCRA-equivalent Cover) poses the least short-term risk since the waste is contained in place and would not be disturbed.

6. Implementability

All alternatives are technically and administratively feasible and rely on readily available equipment, techniques, and on-site disposal facilities. All alternatives can be implemented within the overall schedule for RMA remediation.

For the Lime Basins, issues related to material handling, stability for landfill disposal, odor potential, potential agent contamination and geophysical anomalies were identified for Alternative 2 (Excavate/Landfill). There is sufficient

capacity in the ELF for disposal of all the identified exceedance soil plus the additional soil required for stabilization mixing. Alternative 3 (Vertical Barrier/RCRA-Equivalent Cover) would require evaluation of the groundwater for compatibility with the vertical barrier material. There are no implementation issues identified for Alternative 1 (No Further Action, IRA Cover).

Basin F Alternative 2 (In Situ Solidification/Stabilization of PT Soil), might present implementation issues for full-scale solidification due to potential difficulty in achieving uniform mixing and mobility reduction. Vapor/odor emissions generated during solidification mixing require adequate control measures. Odor control during excavation is the primary implementation issue for Basin F Alternative 3 (Excavate/Landfill PT Soil). Again, adequate control measures are required during excavation, transportation and disposal activities. There is sufficient capacity in the ELF for disposal of all the identified PT soil and the overlying and interbedded HHE soil as well as the odor control soil required. There are no significant implementation issues for construction of the RCRA-equivalent cover (Alternative 1).

Although Basin F Alternative 3 (Excavate/Landfill PT Soil) includes a larger landfill volume than Lime Basins Alternative 2 (Excavate/Landfill), there is sufficient capacity in the ELF for disposal of the exceedance soil for either alternative. However, selection of one of these alternatives precludes the other since there is not sufficient capacity for both.

7. Cost

For the Lime Basins, Alternative 1 (No Further Action, IRA Cover) is the lowest cost alternative, $656,000, with only long-term O&M costs. Alternative 2 (Excavate/Landfill) is the highest cost at $17.1 million. Factors contributing to the high cost of excavating the Lime Basins include material handling to stabilize the waste prior to disposal in the ELF, excavation slope shoring, dewatering, agent monitoring and potential anomaly clearance. Cost for implementing Alternative 3 (Vertical Barrier/RCRA-Equivalent Cover) is approximately $10.9 million.

For Basin F, Alternative 3 (Excavate/Landfill PT Soil) is much lower cost, $14.5 million, than Alternative 2 (In Situ Solidification/Stabilization of PT Soil), $36.2 million. Alternative 1 has no cost associated with it since all costs for RCRA-equivalent cover construction and long-term O&M are already included in the Basin F/Basin F Exterior project.

8. Support Agency Acceptance

The EPA has reviewed the Army's analyses and recommendations and supports their selection of the preferred alternative. The CDPHE supports the preferred alternative.

9. Community Acceptance

Community acceptance will be fully evaluated after the public comment period ends.

SUMMARY OF THE PREFERRED ALTERNATIVES

The preferred remedial alternative for cleanup of the Lime Basins is Alternative 3: Vertical Groundwater Barrier; Dewatering with On-Site Treatment; RCRA-Equivalent

Cover. Alternative 3 provides the best balance of long-term effectiveness and short-term risk at a lower cost than Alternative 2. Alternative 2 provides the least long-term risk but at a higher cost and with much higher short-term risk. Alternative 1 has the lowest cost but results in the highest long-term risk.

For Basin F, the preferred remedial alternative is Alternative 3: Excavate Principal Threat Soil; On-Post Landfill [RCRA-Equivalent Cover]. Alternative 3 carries the highest short-term risk; however it provides the best long-term effectiveness at a lower cost than Alternative 2 and is easier to implement. Alternative 2 provides a reduction in mobility through treatment but is more difficult to implement, costs more and does not provide the long-term effectiveness that Alternative 3 achieves by disposal in the ELF. Alternative 1 has the lowest cost but results in the highest long-term risk.

Together, these alternatives result in containment of a much larger volume of PT soil in the on-site ELF. All project activities would be conducted with appropriate air emission and odor controls as determined during design.

The preferred alternatives were selected over the other alternatives because they provide substantial risk reduction through containment of waste material in the on-post ELF within a reasonable time frame and at a lower cost than the ROD-identified alternatives. The preferred alternatives meet RAOs by containing the waste in the ELF or in place, thereby preventing future exposure to or migration of contaminants. Although the covered waste containment areas will not be transferred to the U.S. Fish and Wildlife Service as part of the refuge, the preferred alternatives will not inhibit use of the remaining RMA property for the anticipated future land use as a wildlife refuge.

Based on the information available at this time, the Army believes the preferred alternatives are the best balance of factors with respect to the balancing criteria. The preferred alternatives are protective of human health and the environment, comply with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, are cost effective and use a permanent solution. In addition, when the preferred alternatives are considered in conjunction with the overall selected remedy in the 1996 ROD, the overall remedy uses a combination of treatment and containment as principal elements to permanently reduce toxicity, mobility or volume of contaminants.

In conjunction with the Army, EPA and CDPHE have reviewed the supporting documents and this Revised Proposed Plan and support their selection of the preferred alternatives. The preferred alternatives may change in response to public comment or new information.

COMMUNITY PARTICIPATION

The Army encourages the public to review all the documentation regarding the Lime Basins and Basin F projects and welcomes your comments on this Revised Proposed Plan. Information concerning these projects and all cleanup efforts at RMA is available to the public at the Joint Administrative Record Document Facility (JARDF) that is located on the RMA in Building 129, Room 2024. Hours of operation and contact telephone numbers are provided on the cover of this document.

The Army also provides information to the public regarding cleanup activities at RMA

through Restoration Advisory Board (RAB) meetings. This board serves as the primary forum through which neighboring communities can receive and share information as well as provide input to the parties involved in the RMA's cleanup.

Prior to issuing this Revised Proposed Plan, the Army provided a discussion of the remedial alternatives being considered for the Lime Basins and Basin F and solicited input from the RAB on the alternatives. Preliminary comments received from the RAB indicated that the preferred alternative is acceptable. This was an opportunity to gain additional public involvement and does not replace the formal public comment period.

The public comment period for this Revised Proposed Plan runs from April 20 through May 20, 2005. A public meeting is scheduled on May 12, 2005. The time and location are provided on the cover of this document.

Written and verbal comments will be accepted at the public meeting or written comments may be addressed to:

Revised Proposed Plan Comments
Rocky Mountain Arsenal
Attn: Peggy Machamer
Public Relations Office
Building 111
Commerce City, CO 80022

Or submitted via e-mail to
pao@rma.army.mil

The Army, in consultation with the EPA and CDPHE, will review all comments received during the public comment period before a final remedial action is selected. The selected remedial actions will be documented in a ROD Amendment for the Lime Basins and Basin F Principal Threat Soil. In response to public comments received, a Responsiveness Summary will be prepared and included in the ROD Amendment. For questions regarding this Revised Proposed Plan, please call (303) 289-0300.

Table 6. Lime Basins Remediation Comparative Analysis of Alternatives

Criteria	ALTERNATIVE 1: NO FURTHER ACTION (IRA SOIL COVER)	ALTERNATIVE 2: EXCAVATE; ON-POST LANDFILL; REPAIR IRA SOIL COVER (ROD REMEDY)	ALTERNATIVE 3: VERTICAL BARRIER; DEWATERING WITH TREATMENT; RCRA-EQUIVALENT COVER
Overall Protection of Human Health and the Environment	*Least Protective*. Exposure prevented by containing waste beneath the existing IRA soil cover; however, biota RAOs are not met since there is no biota barrier included. Groundwater still requires treatment due to contact with Lime Basins material.	*Most Protective*. Exposure prevented by containing waste in the ELF. Impacts to groundwater are minimized through removal and containment in the ELF.	*Substantially Protective*. Exposure prevented by containing waste in place. Impacts to groundwater are minimized through vertical (groundwater barrier wall) and horizontal (RCRA-equivalent cover) containment. Groundwater extracted within barrier wall is treated at existing facilities.
Compliance with ARARs	*Complies* with action-, chemical-, and location-specific ARARs.	*Complies* with action-, chemical-, and location-specific ARARs.	*Complies* with action-, chemical-, and location-specific ARARs.
Long-Term Effectiveness and Permanence	*Highest residual risk*. Relies on containment beneath existing IRA soil cover to reduce migration and exposure. Waste remains in contact with groundwater.	*Least residual risk*. Relies on disposal in ELF to prevent migration and exposure.	*Moderate residual risk*. Relies on containment from vertical groundwater barrier and RCRA-equivalent cover to reduce migration and exposure. Groundwater extracted from within barrier wall enhances effectiveness.
Reduction of Toxicity, Mobility, or Volume (TMV) through Treatment	No reduction in toxicity, mobility or volume through treatment.	No reduction in toxicity, mobility, or volume through treatment.	Treatment of extracted groundwater reduces the toxicity and volume of contaminants. No reduction in mobility through treatment.
Short-Term Effectiveness	*Least short-term risk*. No intrusive activity or contaminated material handling. Waste is left in place beneath existing IRA soil cover. No air/odor impacts.	*Highest short-term risk* to workers and community from potential emissions and odors during soil excavation, stabilization mixing, transportation, and disposal of principal threat and human health exceedance soil. Risks manageable through adequate odor/emission control and material handling procedures. Highest risk to workers due to potential for encountering ordnance or chemical agent during excavation activities.	*Moderate short-term risk*. Lime Basins material is not disturbed as the vertical barrier is installed outside of the basin footprints. Waste is left in place and covered with RCRA-equivalent cover. Minimal air/odor emissions during barrier installation are adequately controlled. Some risk to workers during barrier wall construction due to potential for encountering ordnance or chemical agent.
Implementability	*Easiest to Implement*. No implementation required beyond long-term groundwater monitoring. Implementation time is 12 months.	*Most difficult to Implement*. Readily available technologies. ELF available to accept material, provided waste acceptance criteria are met. Additional material handling to stabilize the waste increases the potential for emissions/odors and requires multiple handlings of material in order to achieve placement in the ELF. Vapor/odor emissions generated during excavation, stabilization mixing, stockpiling, transportation and placement in ELF require adequate control measures. Agent screening and anomaly management (potential OE presence) may impact excavation productivity. Long-term groundwater monitoring required. Implementation time is 21 months.	*Difficult to Implement*. Readily available technologies. Verification of barrier to groundwater compatibility required. Treatment capacity required for groundwater extracted from within barrier wall. Cover easily implementable. Agent monitoring and geophysical clearance required during barrier wall construction may impact productivity. Long-term groundwater monitoring required. Implementation time is 18 months.
Cost	*Least Cost.* Long-term monitoring cost estimated at $656,000.	*Highest Cost*. Estimated cost is $17,100,000.	*Moderate Cost*. Estimated cost is $10,900,000.
Conclusion	Lowest cost but highest risk for long-term effectiveness.	Highest cost. Best long-term effectiveness but with highest short-term risks and most difficult to implement.	*Preferred*. Best balance of short-term risks, long-term effectiveness and overall costs.
Support Agency Acceptance	EPA has reviewed the Army's analyses and recommendations and supports their selection of the preferred alternative. CDPHE supports the preferred alternative, Alternative 3: Vertical Groundwater Barrier; Dewatering/Treatment; RCRA-Equivalent Cover.		
Community Acceptance	Community acceptance will be fully evaluated after the public comment period ends.		

Table 7. Basin F Principal Threat Soil Remediation Comparative Analysis of Alternatives

Criteria	ALTERNATIVE 1: NO FURTHER ACTION [RCRA-EQUIVALENT COVER]	ALTERNATIVE 2: IN SITU SOLIDIFICATION/STABILIZATION; [RCRA-EQUIVALENT COVER] (ROD REMEDY)	ALTERNATIVE 3: EXCAVATE; ON-POST LANDFILL [RCRA-EQUIVALENT COVER]
Overall Protection of Human Health and the Environment	*Least Protective*. Exposure prevented by containing waste in place. Impacts to groundwater reduced by the RCRA-equivalent cover. . Groundwater treated at existing boundary treatment facilities.	*Substantially Protective*. Exposure prevented by containing waste in place. Future impacts to groundwater are minimized by decreasing permeability of waste soil and containment beneath RCRA-equivalent cover. Groundwater treated at existing boundary treatment facilities.	*Most Protective*. Exposure prevented by containing principal threat waste less than 10 ft depth in the ELF. Residual soil remaining in Basin F is contained in place beneath the RCRA-equivalent cover. Impacts to groundwater from principal threat soils are decreased through removal and containment in the ELF. Groundwater treated at existing boundary treatment facilities.
Compliance with ARARs	*Complies* with action-, chemical-, and location-specific ARARs.	*Complies* with action-, chemical-, and location-specific ARARs.	*Complies* with action-, chemical-, and location-specific ARARs.
Long-Term Effectiveness and Permanence	*Highest residual risk*. Relies on containment beneath RCRA-equivalent cover to reduce migration and exposure.	*Moderate residual risk*. Relies on containment beneath RCRA-equivalent cover and solidification to minimize migration and exposure. Groundwater treated at existing treatment facilities.	*Least residual risk*. Relies on disposal in ELF and containment of remaining waste beneath RCRA-equivalent cover to prevent migration and exposure. Groundwater treated at existing treatment facilities.
Reduction of Toxicity, Mobility, or Volume (TMV) through Treatment	No reduction in toxicity, mobility or volume through treatment.	Mobility of contaminants reduced through treatment (solidification). No reduction in toxicity; and the volume increases due to addition of solidification reagents.	No reduction in toxicity, mobility, or volume through treatment.
Short-Term Effectiveness	*Least short-term risk*. No intrusive activity or contaminated material handling. Waste is left in place and covered with RCRA-equivalent cover. No air/odor impacts.	*Moderate short-term risk* to workers and community from potential emissions and odors during in-place soil mixing for solidification of principal threat soil. Risks manageable through adequate odor/emission control and material handling procedures.	*Highest short-term risk* to workers and community from potential emissions and odors during soil excavation, transportation, and disposal of principal threat and human health exceedance soil. Risks manageable through adequate odor/emission control and material handling procedures.
Implementability	*Easiest to Implement*. No implementation required beyond RCRA-equivalent cover and long-term groundwater monitoring. Implementation time is 12 months.	*Most Difficult to Implement*. Readily available technology. Potential difficulties in achieving uniform mixing of soil and reagents to provide consistent mobility reduction through entire principal threat volume. Vapor/odor emissions generated during solidification mixing require adequate control measures. Long-term groundwater monitoring required. Implementation time is 29 months.	*Moderate Difficulty to Implement*. Readily available technology. ELF available to accept material, provided waste acceptance criteria is met. Vapor/odor emissions generated during excavation, transportation and placement in ELF require adequate control measures. Implementation time is 26 months.
Cost	*Least Cost*. Costs associated with cover construction and long-term groundwater monitoring are included in the Basin F/Basin F Exterior project.	*Highest Cost*. Estimated cost is $36,200,000.	*Moderate Cost*. Estimated cost is $14,500,000.
Conclusion	Lowest cost but highest risk for long-term effectiveness.	Highest cost and most difficult to implement. Achieves reduction in mobility through treatment and has moderate short-term risks and residual risks.	*Preferred*. Best balance of protectiveness, implementability and long-term effectiveness as well as cost effective.
Support Agency Acceptance	EPA has reviewed the Army's analyses and recommendations and supports their selection of the preferred alternative. CDPHE supports the preferred alternative, Alternative 3: Excavate Principal Threat Soil; On-Post Landfill [RCRA-Equivalent Cover].		
Community Acceptance	Community acceptance will be fully evaluated after the public comment period ends.		

GLOSSARY

Applicable or Relevant and Appropriate Requirements (ARARs) – Federal and state requirements that a selected remedy for a site will meet.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) – Also known as Superfund, a law passed in 1980 that establishes a program to identify abandoned or inactive hazardous waste sites, ensure they are cleaned up, evaluate damages to natural resources, and create claims procedures for parties remediating sites.

Contaminant of Concern (COC) – A chemical selected for evaluating potential human or animal health effects. Selection is based on concentration, toxicity, or site-specific information.

Detailed Analysis of Alternatives (DAA) – A Feasibility Study document that provides a detailed evaluation of remedial alternatives for a site. The DAA presents detailed descriptions of remedial alternatives, individual and comparative analyses against the CERCLA criteria, and provides the basis for making a remedy selection.

Enhanced Hazardous Waste Landfill (ELF) – A triple-lined disposal facility for wastes and contaminated soil. Hazardous waste landfills are secure disposal sites that are specially designed to contain the potential release of hazardous substances into the environment.

Feasibility Study (FS) – An investigation that serves as the mechanism for the development, screening and evaluation of remedial alternatives. It usually is begun as soon as the Remedial Investigation (RI) is underway; together they are commonly referred to as the RI/FS. The RI/FS serves as the basis to support selection of an appropriate remedy for the site.

Federal Facility Agreement (FFA) – The legal document that sets the framework for cleanup at the RMA.

Groundwater barrier wall – A buried vertical barrier to groundwater movement commonly made of a soil and clay mixture.

Human Health Risk Exceedance (HHE) soil – Areas of soil where concentrations of chemicals of concern are sufficiently high that the calculated excess human health cancer risk is greater than 10^{-4} and the noncarcinogenic human health exposure index is greater than 1.0.

Interim Response Action (IRA) – A remedial action that is implemented in an expedited time frame before the final remedy and that has been determined to be necessary and appropriate for the site.

National Contingency Plan (NCP) [National Oil and Hazardous Substances Pollution Contingency Plan] – The federal regulations that govern the implementation of CERCLA.

Operable Unit – The term for a geographic area or a separate activity undertaken as part of a cleanup conducted under CERCLA.

Paint Filter Test (PFT) – A test used to determine if free liquids are present in a material. Free liquids are liquids which readily separate from the solid portion of the material under ambient temperature and pressure. Under RCRA Subtitle C, materials containing free liquids cannot be directly disposed to a landfill.

Principal Threat (PT) – Soil that is considered to be highly toxic or highly mobile that would present a significant risk to human health should an exposure occur (human health cancer risk greater than 10^{-3} or a noncarcinogenic human health exposure index greater than 1,000).

RCRA-Equivalent Cover – An alternative soil cover to a full Resource Conservation and Recovery Act cap that is compliant with RCRA Subtitle C hazardous waste regulations. The RCRA-equivalent cover is an evapo-transpiration cover and has been demonstrated to meet Subtitle C performance criteria within the semi-arid Denver climate. The cover is sloped to drain rain and snow away from the cover and is seeded with native plant species that, when mature, will transport moisture out of the cover soil. At RMA, the approved RCRA-equivalent cover is composed of four feet of compacted soil and includes an 18-inch-thick high-density concrete cobble biota intrusion barrier.

Record of Decision (ROD) – A public document that records and explains the cleanup alternatives to be used at a CERCLA site. It is based on information from the Remedial Investigation/Feasibility Study, public comments, and community concerns.

Refuge Act – Rocky Mountain Arsenal National Wildlife Refuge Act of 1992. Public Law 102-402. Legislation enacted October 9, 1992 creating the Rocky Mountain Arsenal National Wildlife Refuge pursuant to completion of remedial actions described in the Record of Decision.

Remedial Action Objectives (RAOs) – Provides general guidance for the Feasibility Study by identifying the contaminants and media of interest, potential exposure pathways, and preliminary remediation goals.

Remedial Alternative – An option for cleaning up a site.

Remedial Investigation (RI) – A study that reports the types, amounts, and locations of contamination at a site.

Solidification/Stabilization – A process in which a special mixture (cement-based or other compounds) is combined with contaminated soil. The mixture is allowed to harden, fixing the contaminants and soil in a solid mass. In situ solidification/stabilization uses mixing or drilling equipment to mix the solidification/stabilization compounds and contaminated soil in place.